Review of INFN SEY measurements and progress on electron energy analysers.

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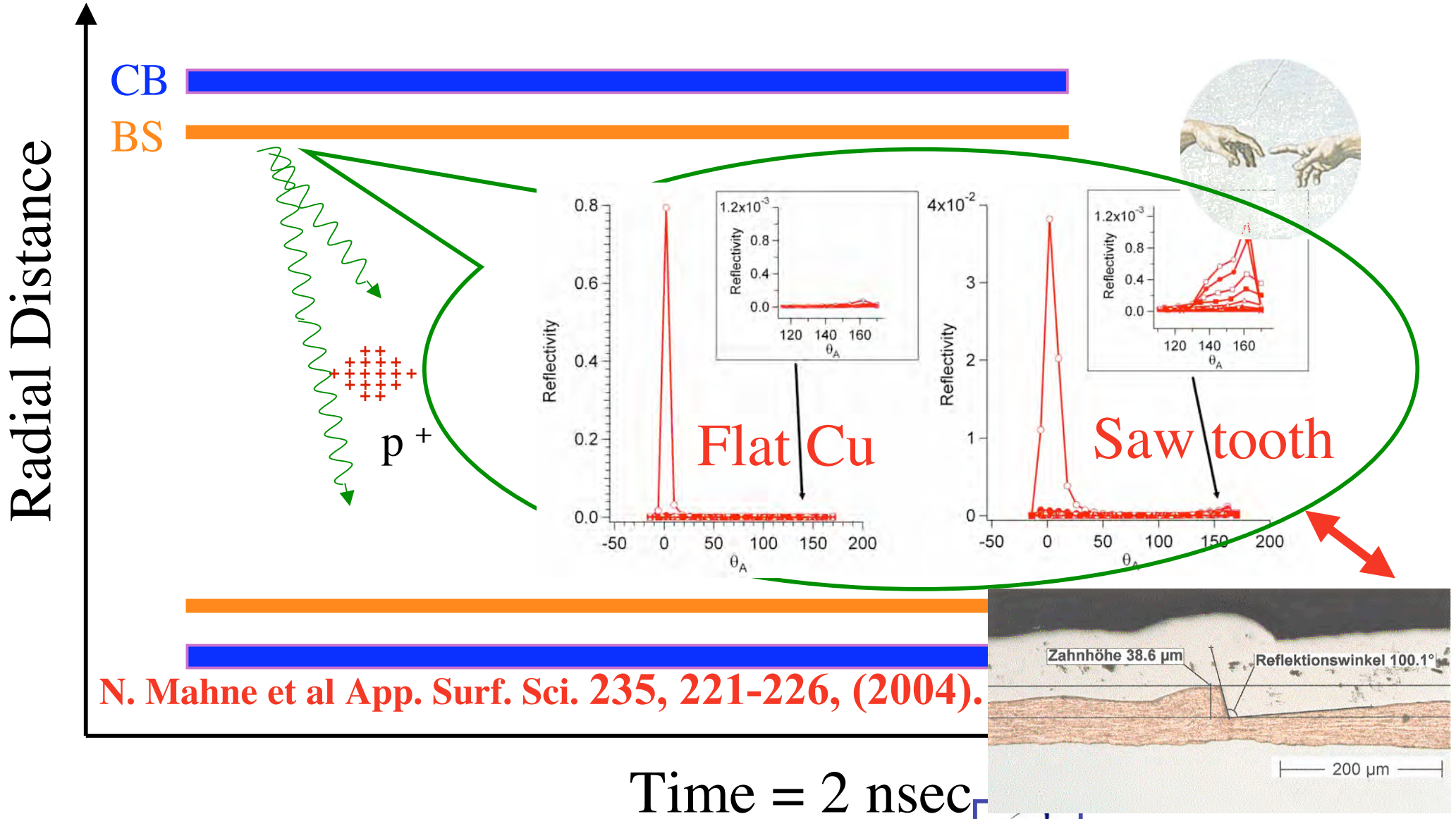
- The e- cloud problem: a brief review of INFN-LNF results using Surface Science.
- Some selected results on Scrubbing
- Future work and implications

Surface science inputs :

1) 0-1keV Electron induced el. emission yield (SEY)
2) and its angular dependence
3) Photoemission Yield and Photoemission induced el. energy distribution (also *Angle resolved!*)
4) Photon - reflectivity
5) Electron induced energy distribution curves
6) Heat load
7) Photon and electron induced desorption
8) Surface properties changes during conditioning.
9) Chemical modifications vs. conditioning.
10) Relation between photon and electron conditioning.

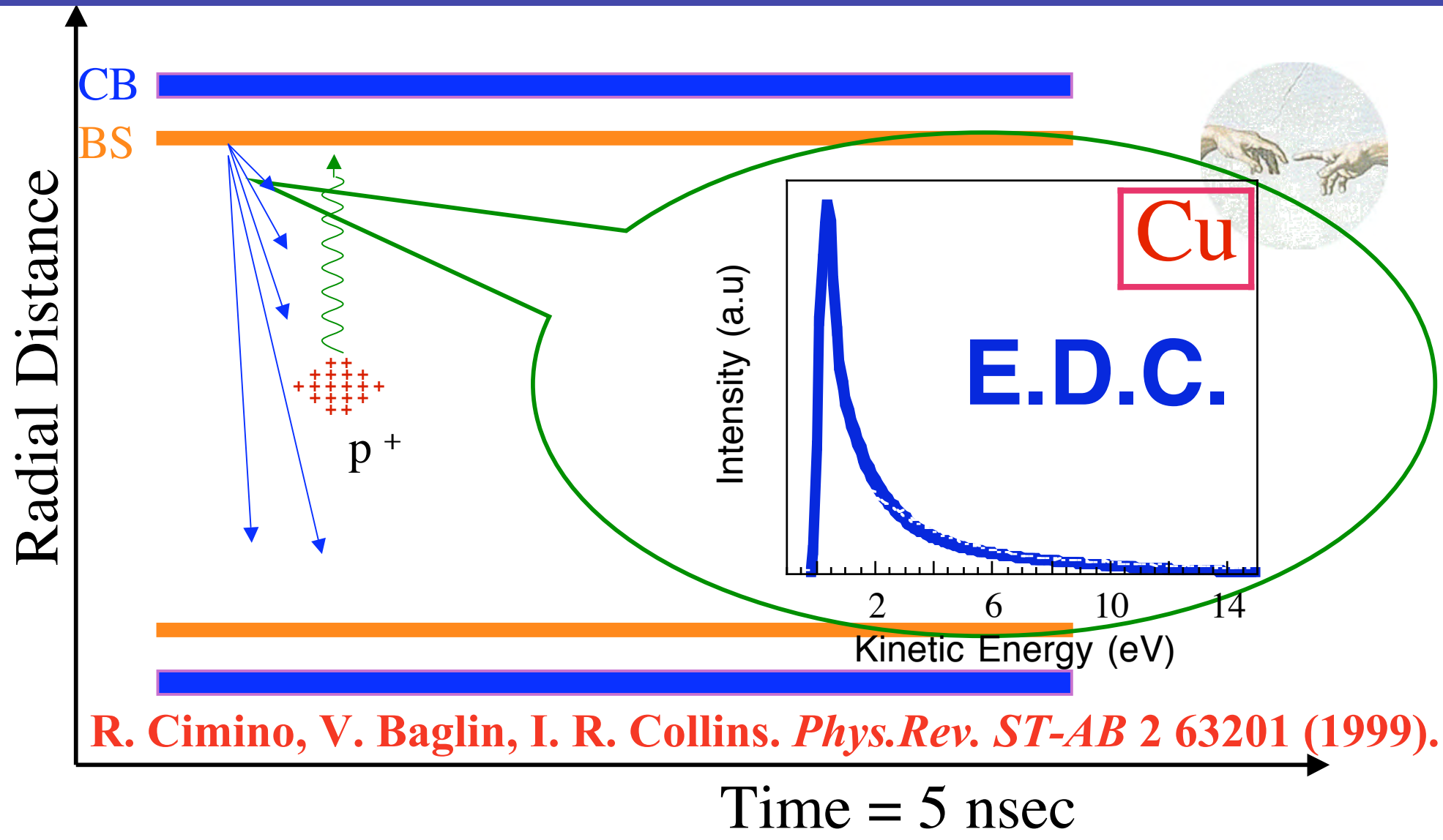
… and this on all vacuum high tech. materials…

We studied: Photon reflectivity



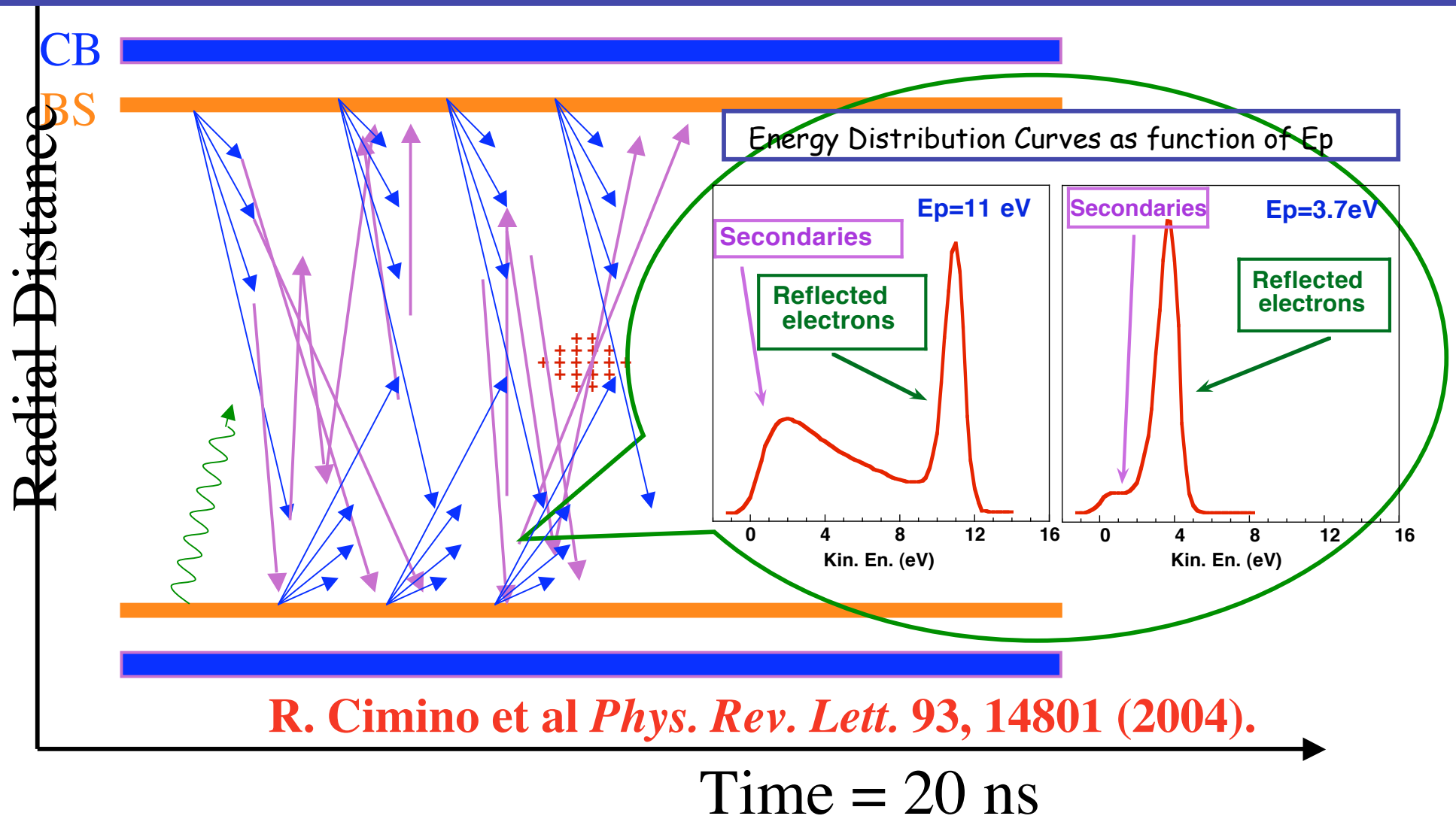
N. Mahne et al App. Surf. Sci. 235, 221-226, (2004).

We studied: Photoemission (vs. hν, Θ, E,T, B)



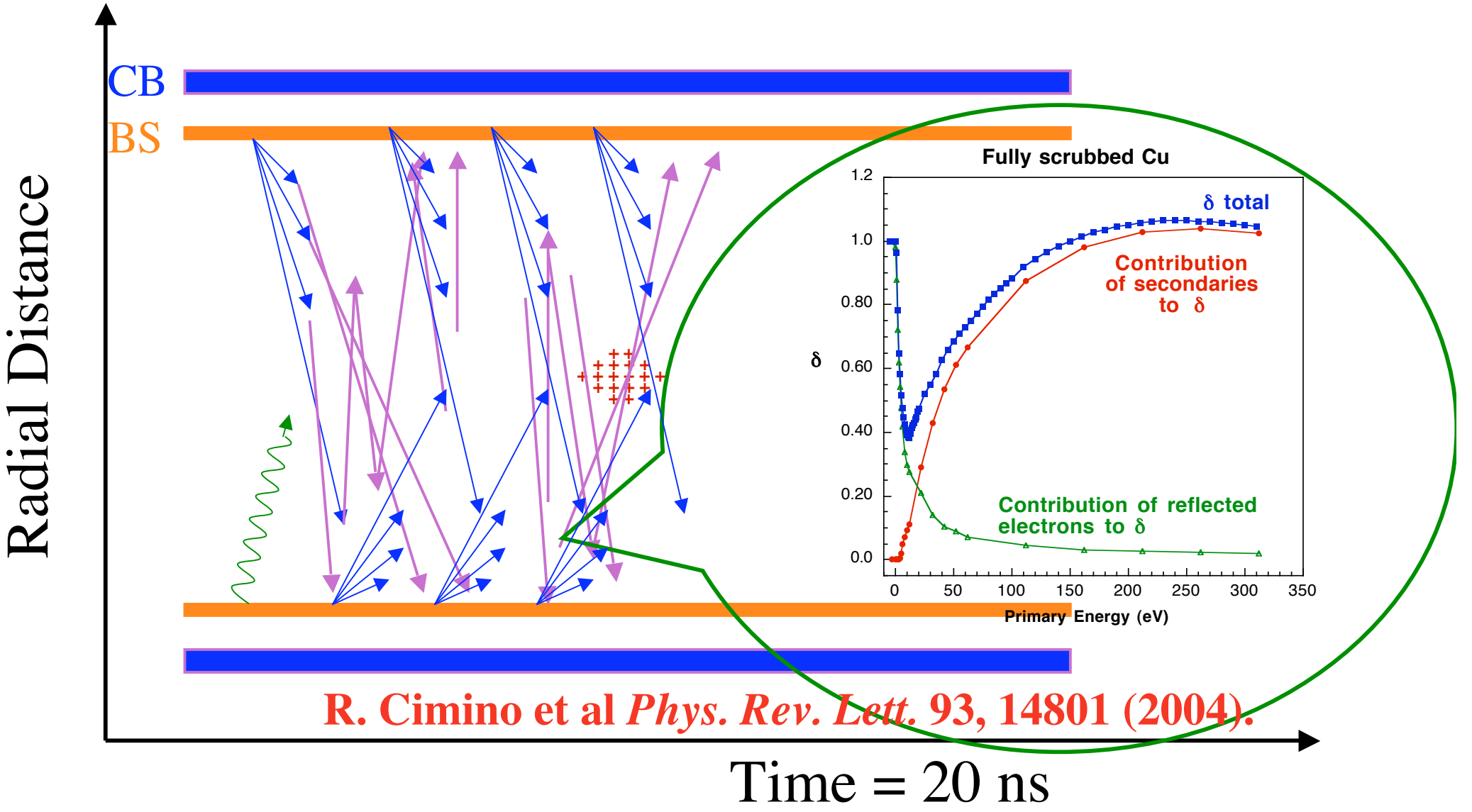
R. Cimino, V. Baglin, I. R. Collins. *Phys.Rev. ST-AB* 2 63201 (1999).

We studied: e^- induced e^- emission vs. E



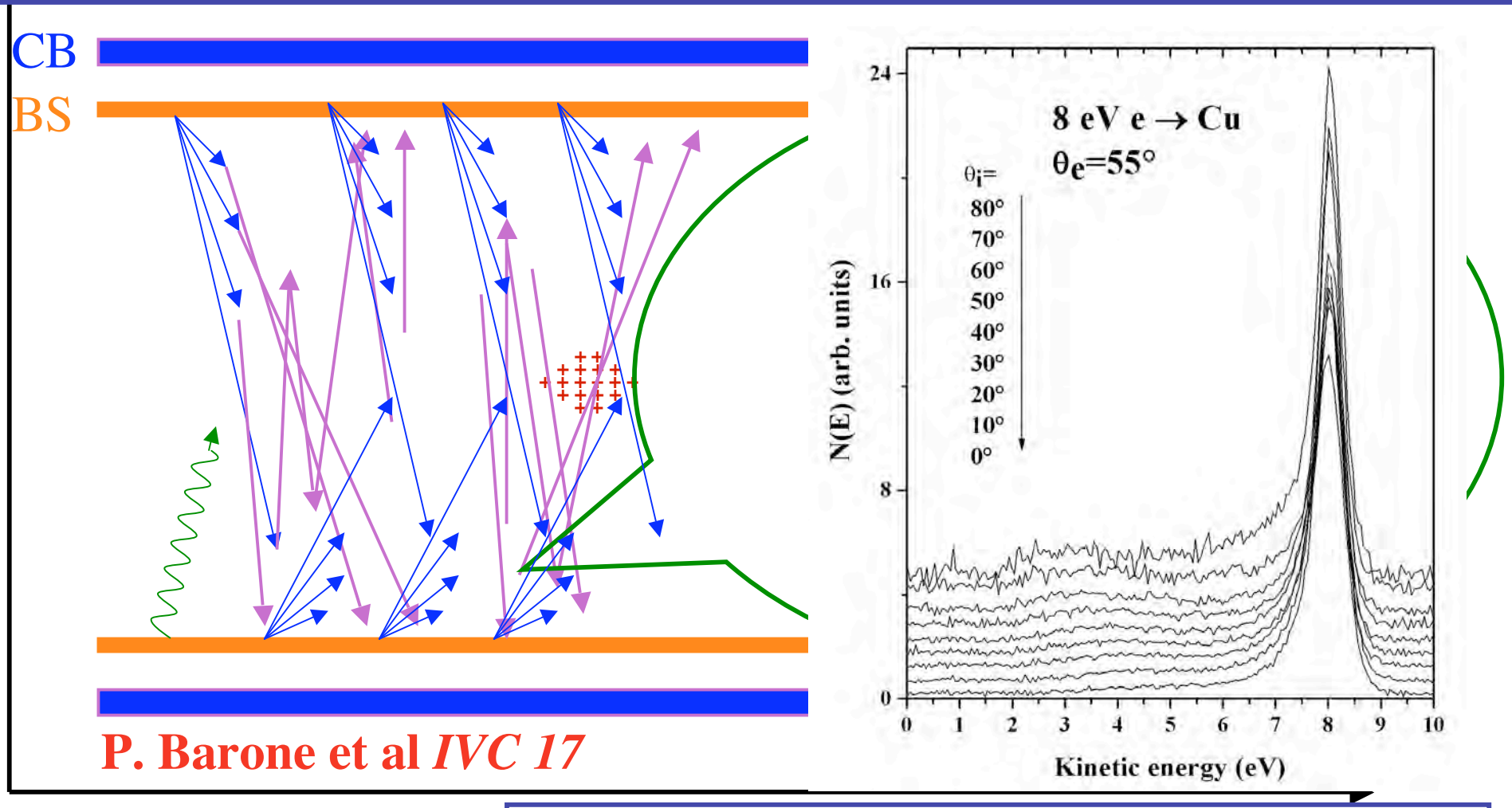
R. Cimino et al *Phys. Rev. Lett.* 93, 14801 (2004).

We studied: SEY @ Low energy



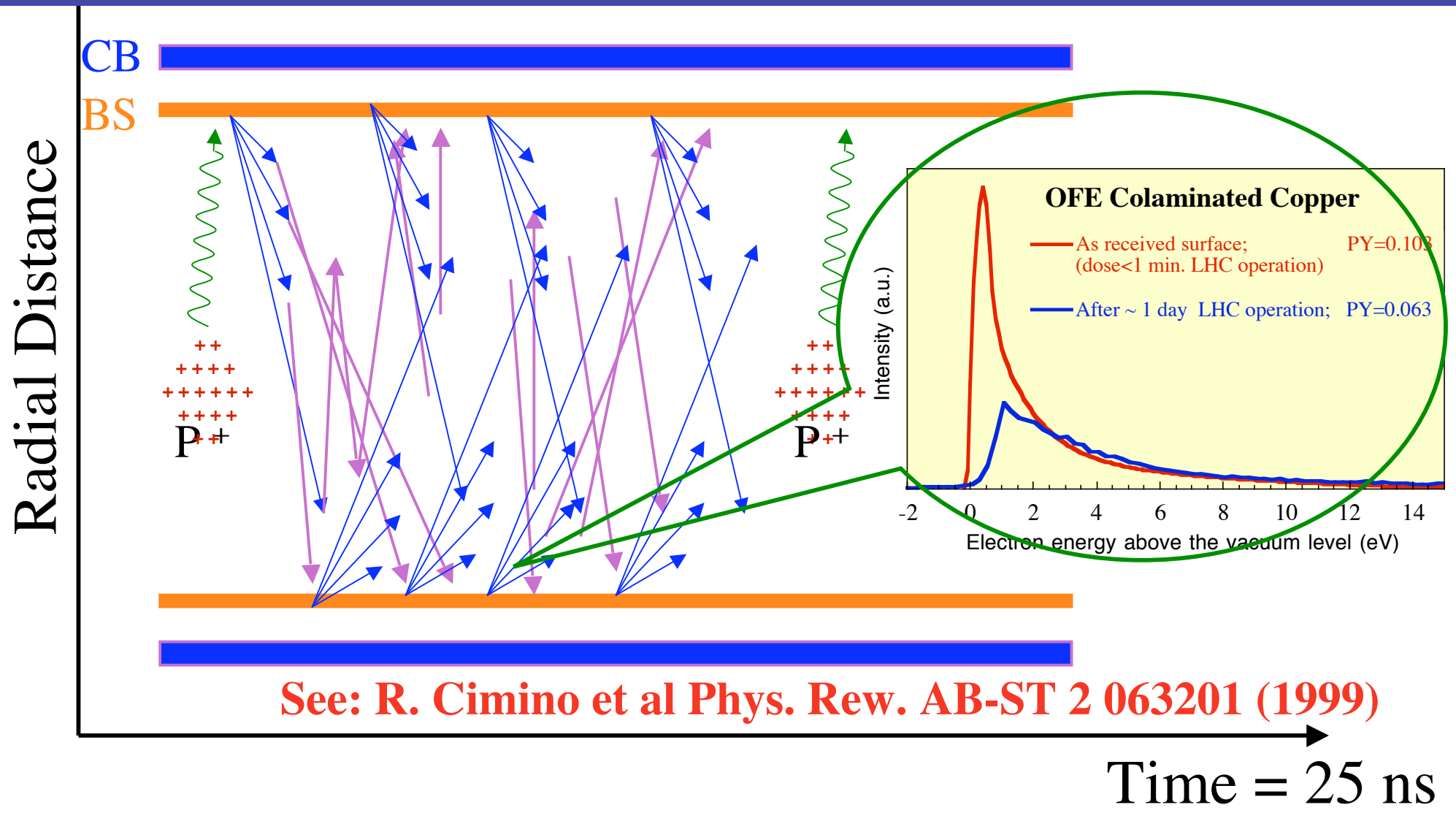
R. Cimino et al *Phys. Rev. Lett.* 93, 14801 (2004).

We studied: e⁻ induced e⁻ emission vs. Emission Angle



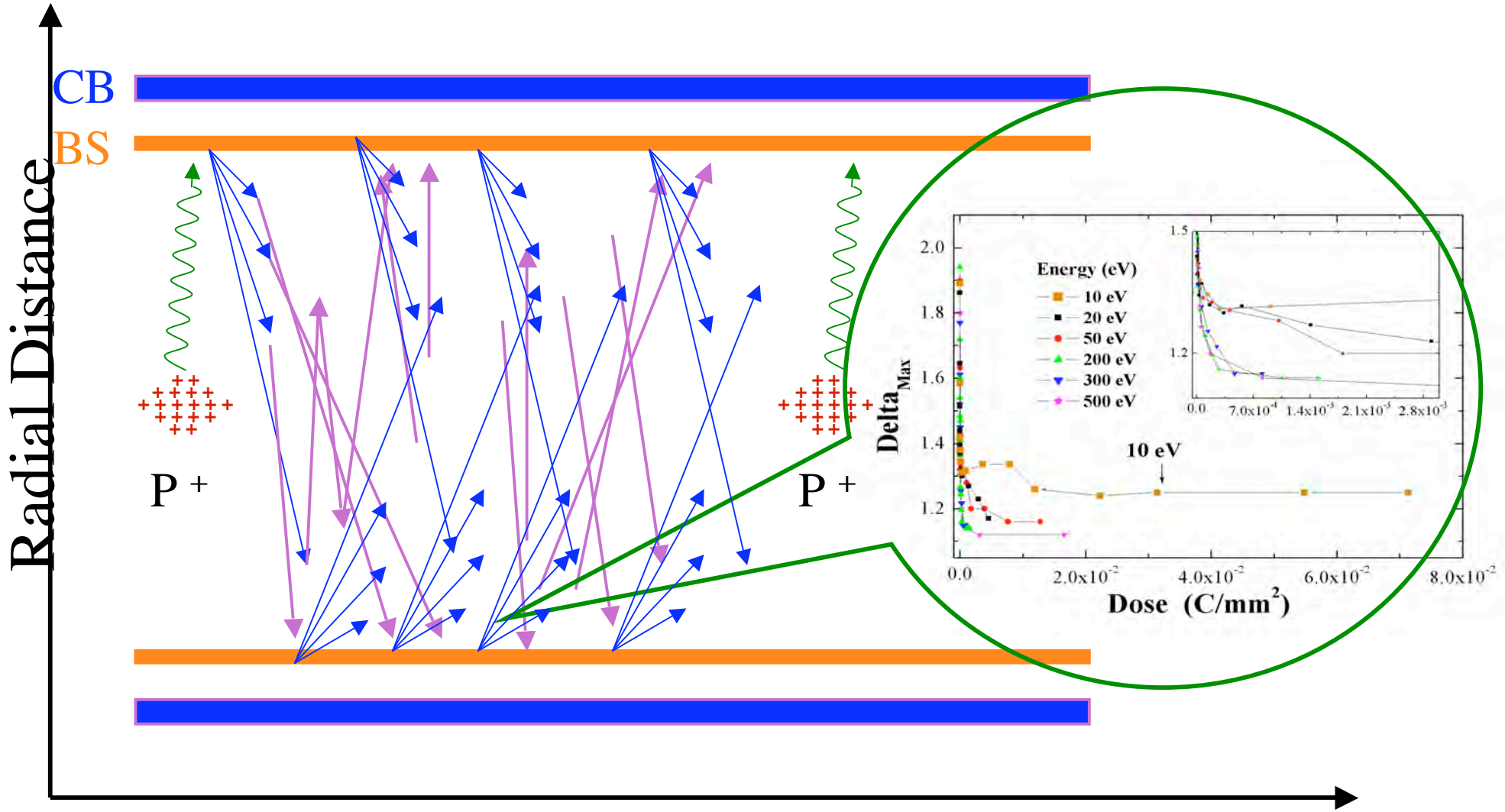
(EDC) from Cu surface vs. incident angle θ_i at a fixed observation angle θ_e=55°,

We studied: Beam scrubbing effect with photon



See: R. Cimino et al Phys. Rew. AB-ST 2 063201 (1999)

We studied: Beam scrubbing effect with e^-



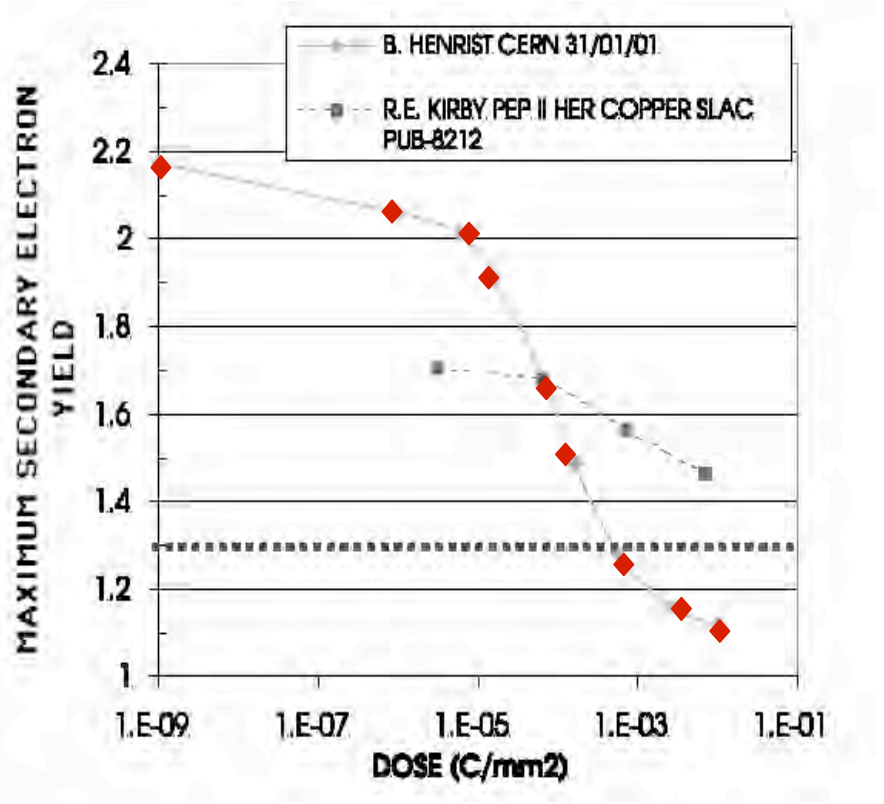
The nominal LHC operation relies on ***SCRUBBING***

beam scrubbing effect in details: why?

from LHC PR 472 (Aug. 2001):

"…Although the phenomenon of conditioning has been obtained reproducibly on many samples, the exact mechanism leading to this effect is not properly understood. This is of course not a comfortable situation as the LHC operation at nominal intensities relies on this effect…"

The detailed study of the observed SEY reduction with dose, can give a deeper understanding on the processes occurring at surfaces and on the real Scrubbing efficiency.



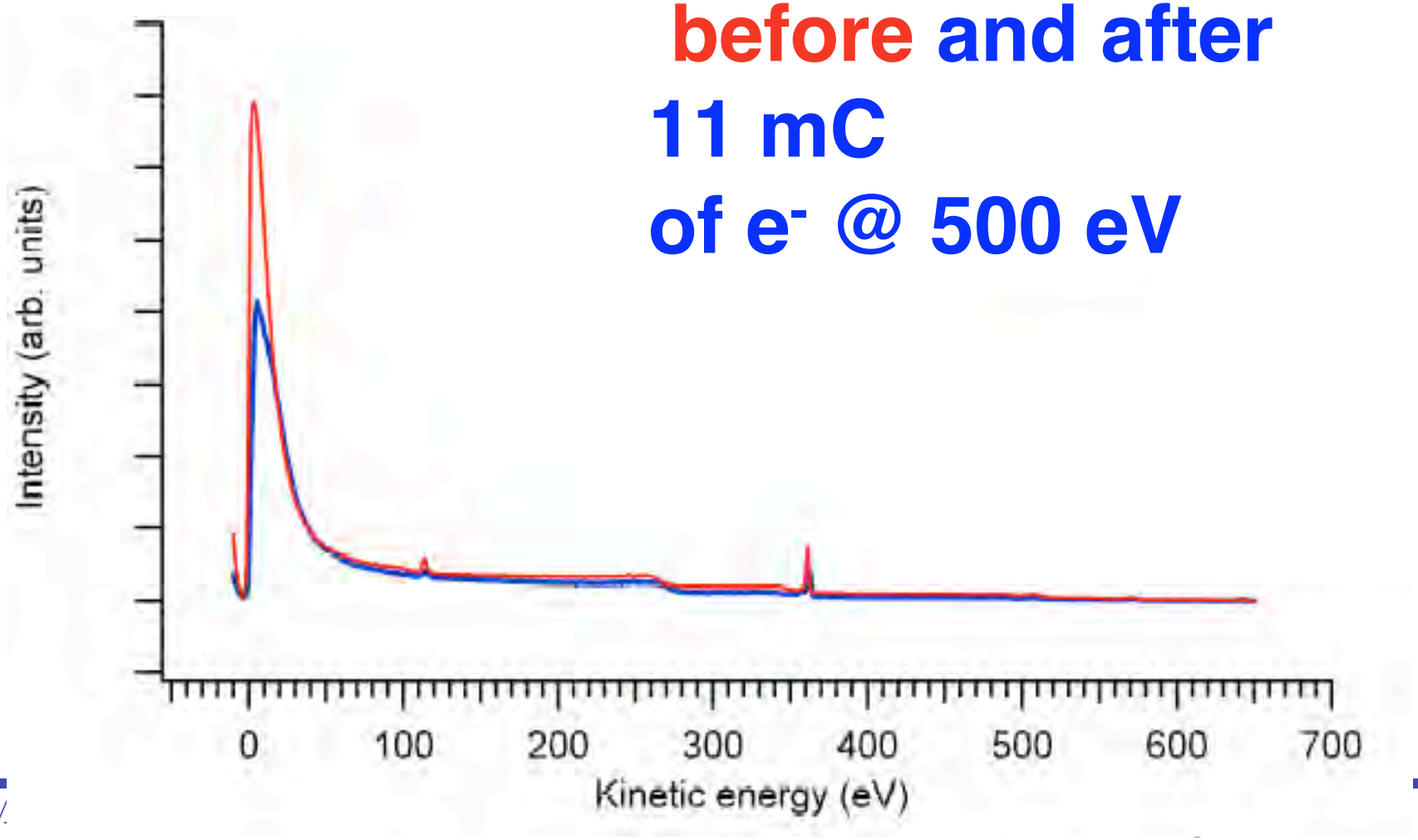
beam scrubbing effect in details: how?

- Indeed beam induced conditioning (or scrubbing) acts by modifying surface properties and, therefore, can and should be studied by SS techniques!!!

Synchrotron radiation studies can tell us a lot on such chemical processes.

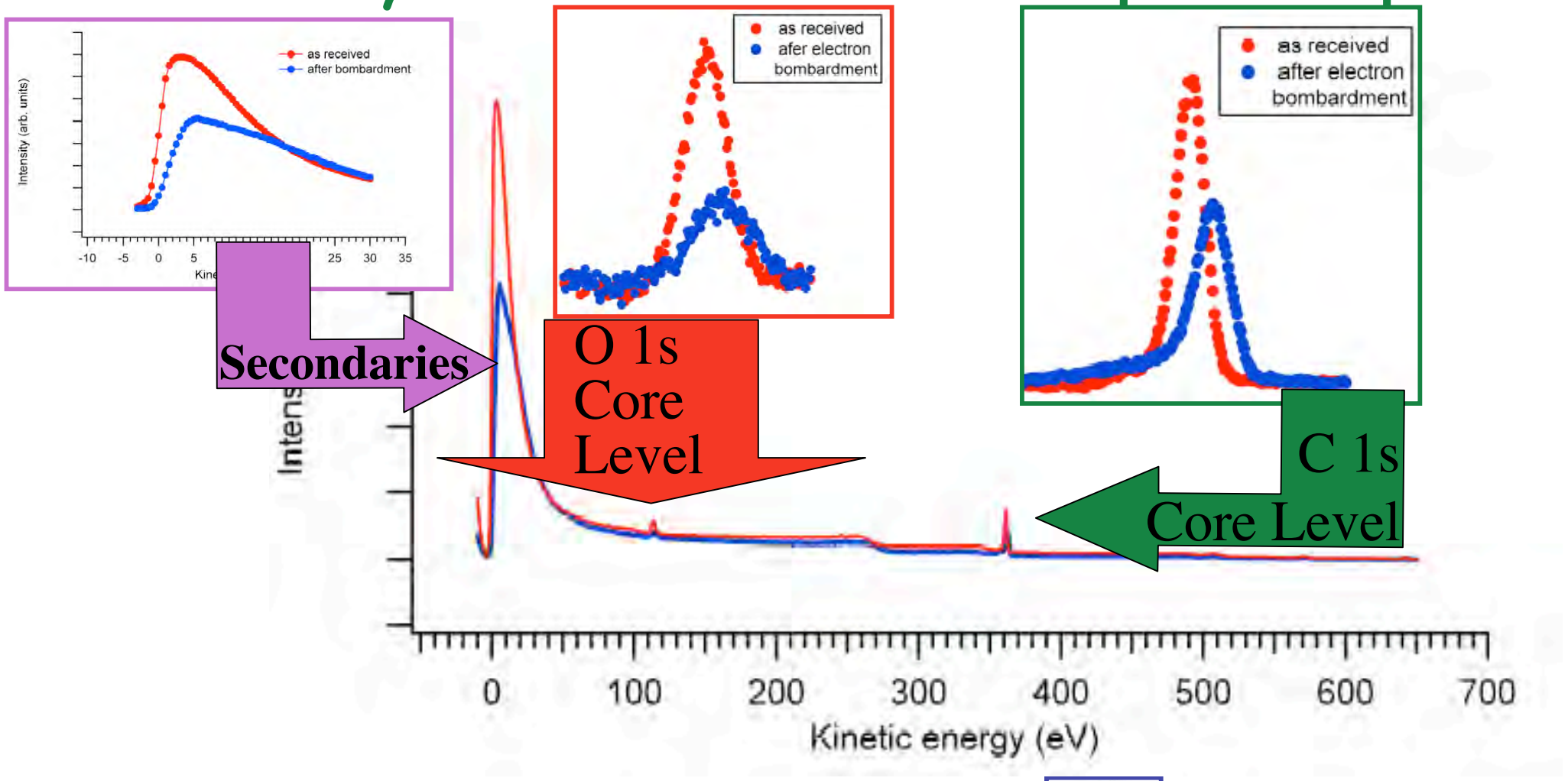
beam scrubbing effect in details: how?

1. We can study surface chemistry variation vs. scrubbing with CL photoemission



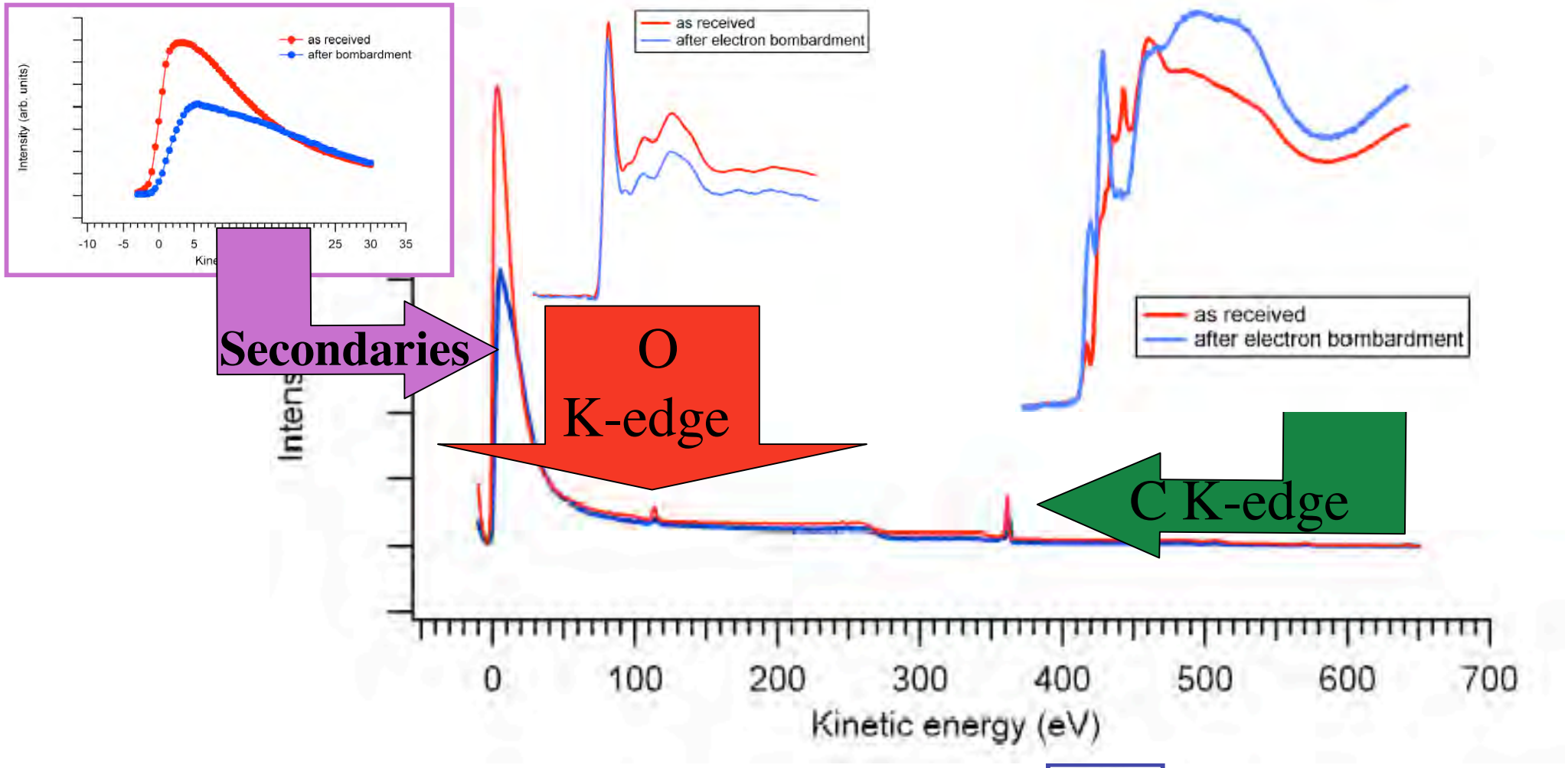
Surface Science vs. Scrubbing on Cu

We can analyze differences with SR-spectroscopies



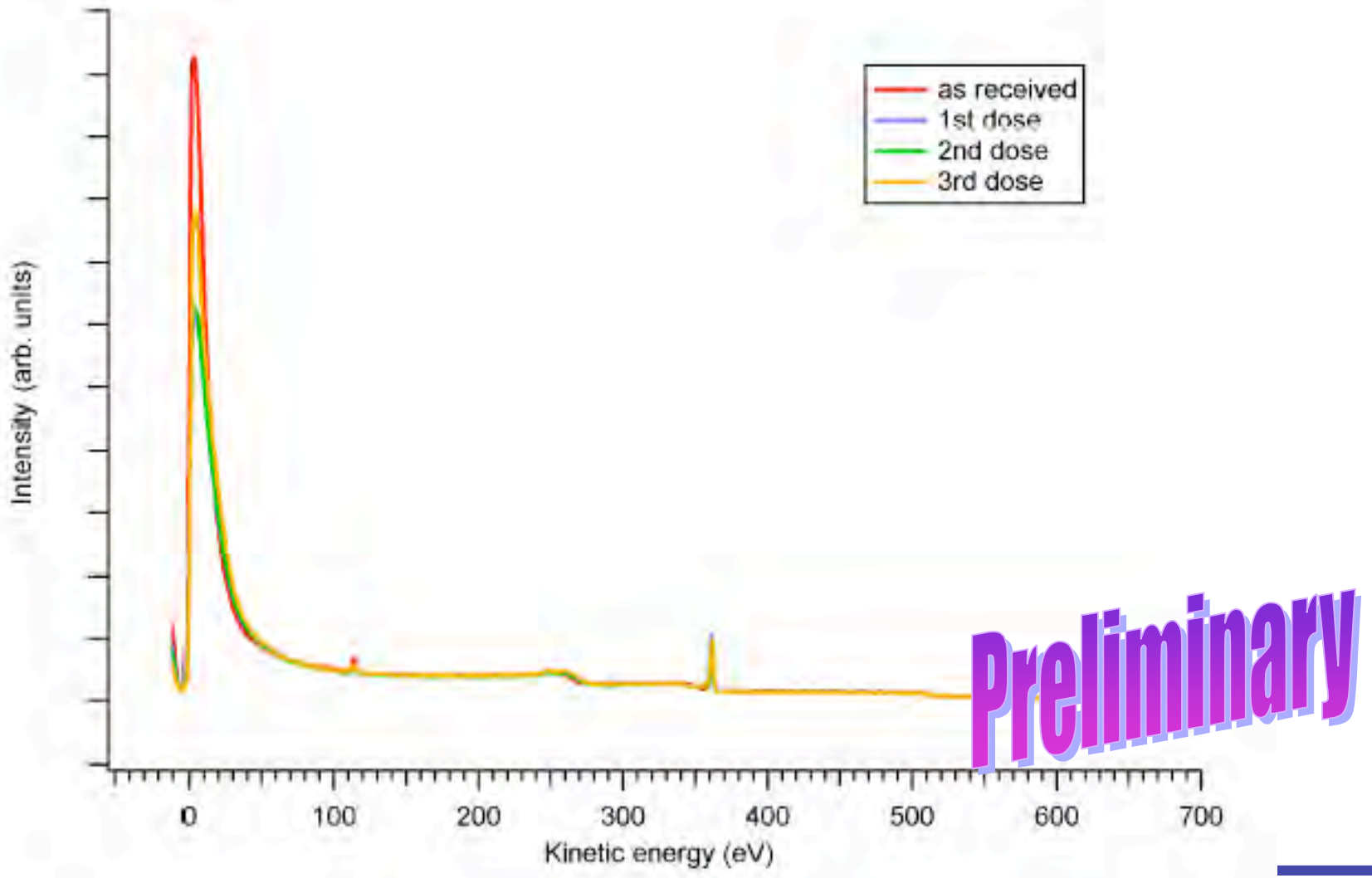
Surface Science vs. Scrubbing on Cu

We can analyze differences with X-ray Absorbtion



Surface Science vs. Scrubbing (3).

We can study also the chemistry of photon scrubbing



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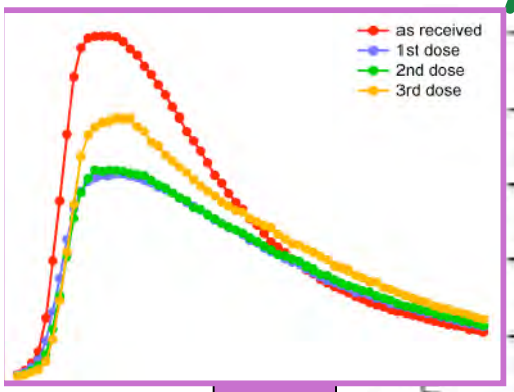
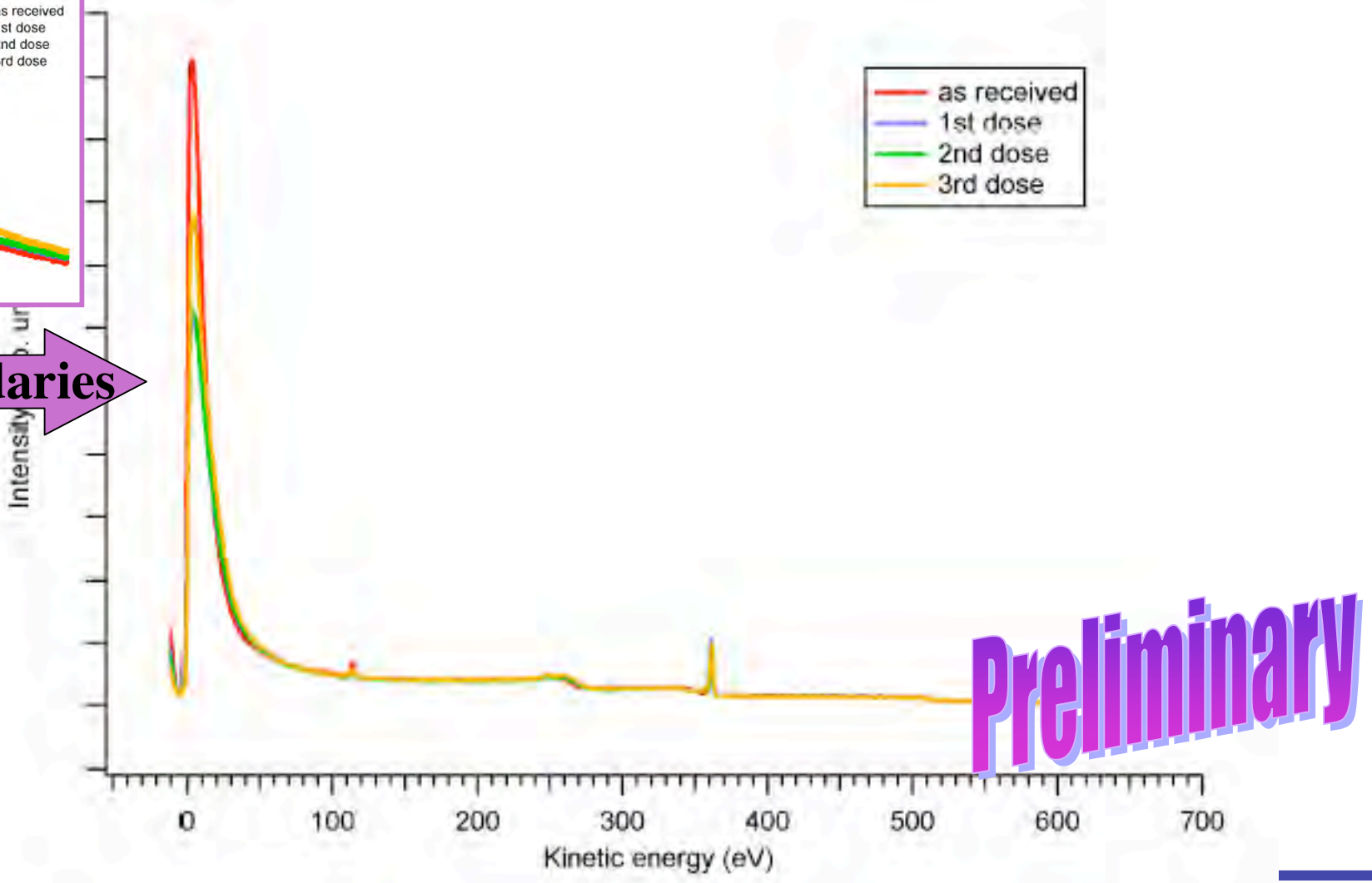


Secondaries



Preliminary

Surface Science vs. Scrubbing (3).

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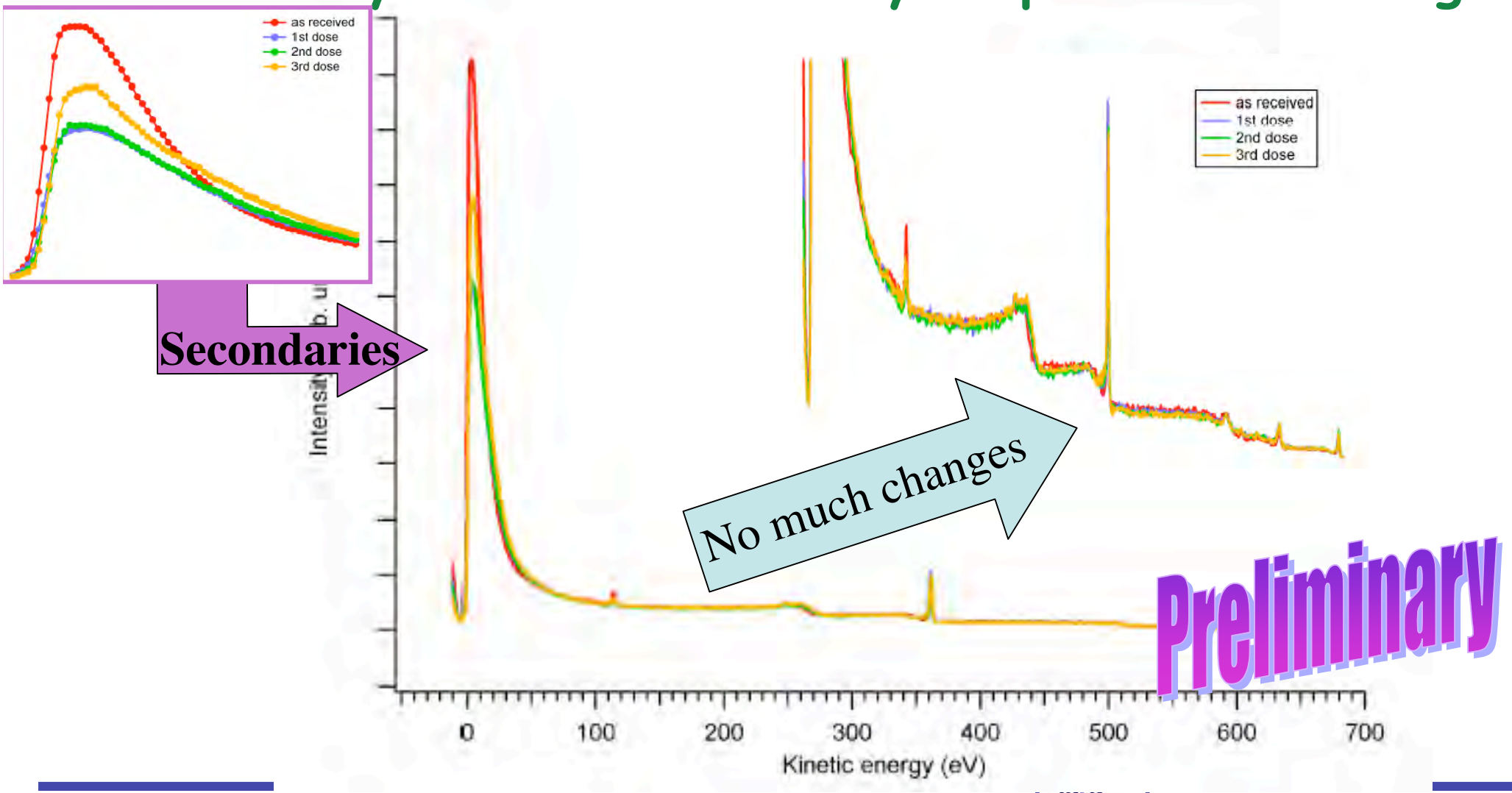

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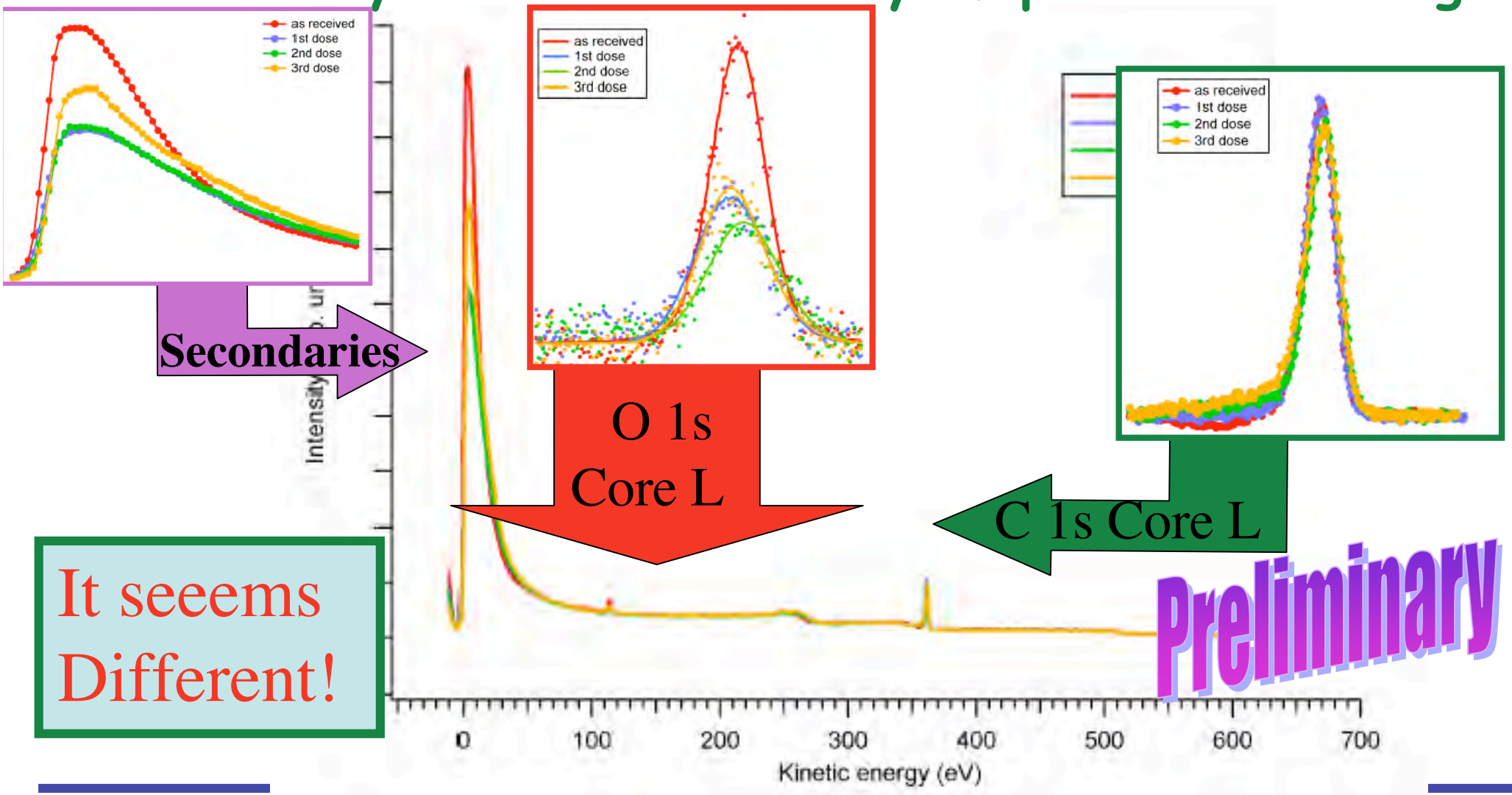


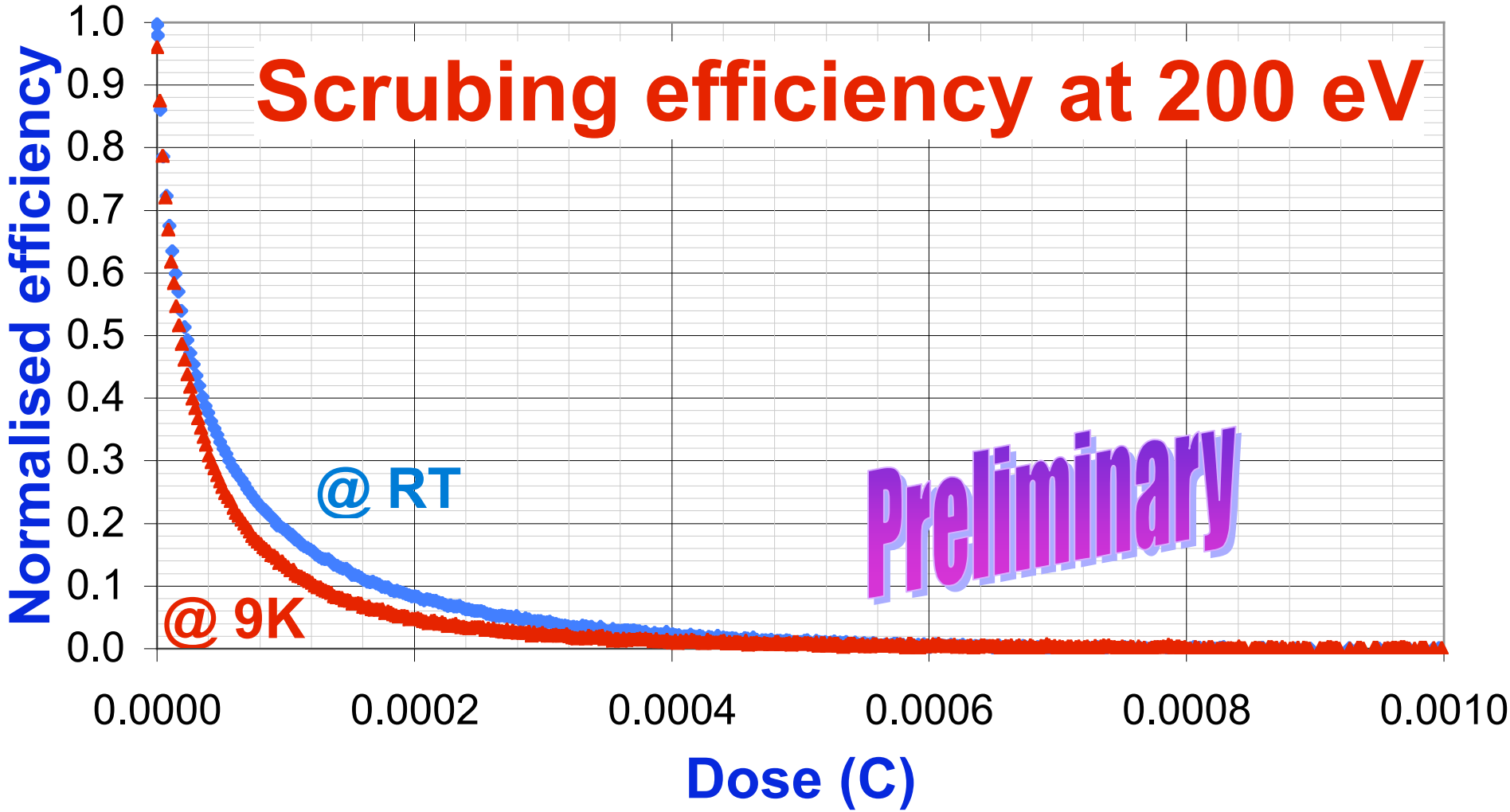
Are there differences between Scrubbing in the laboratory and in the machine?

1. Typically scrubbing experiments are done at RT. Does scrubbing changes at LT?

2. Lab. exp. are done in an "open geometry" while the machine is in a "close geometry", does it matter?

3. Scrubbing experiments in the lab are typically done using 500 eV electrons, than Scrubbing efficiency is given in e^- dose:
   Dose= N°e^- (Amps) x t(s) /A (mm^2)
   But:
   does 100 e^- @ 500 eV scrub as 100 e^- @ 10 eV?

1. Does the scrubbing efficiency depends on T?

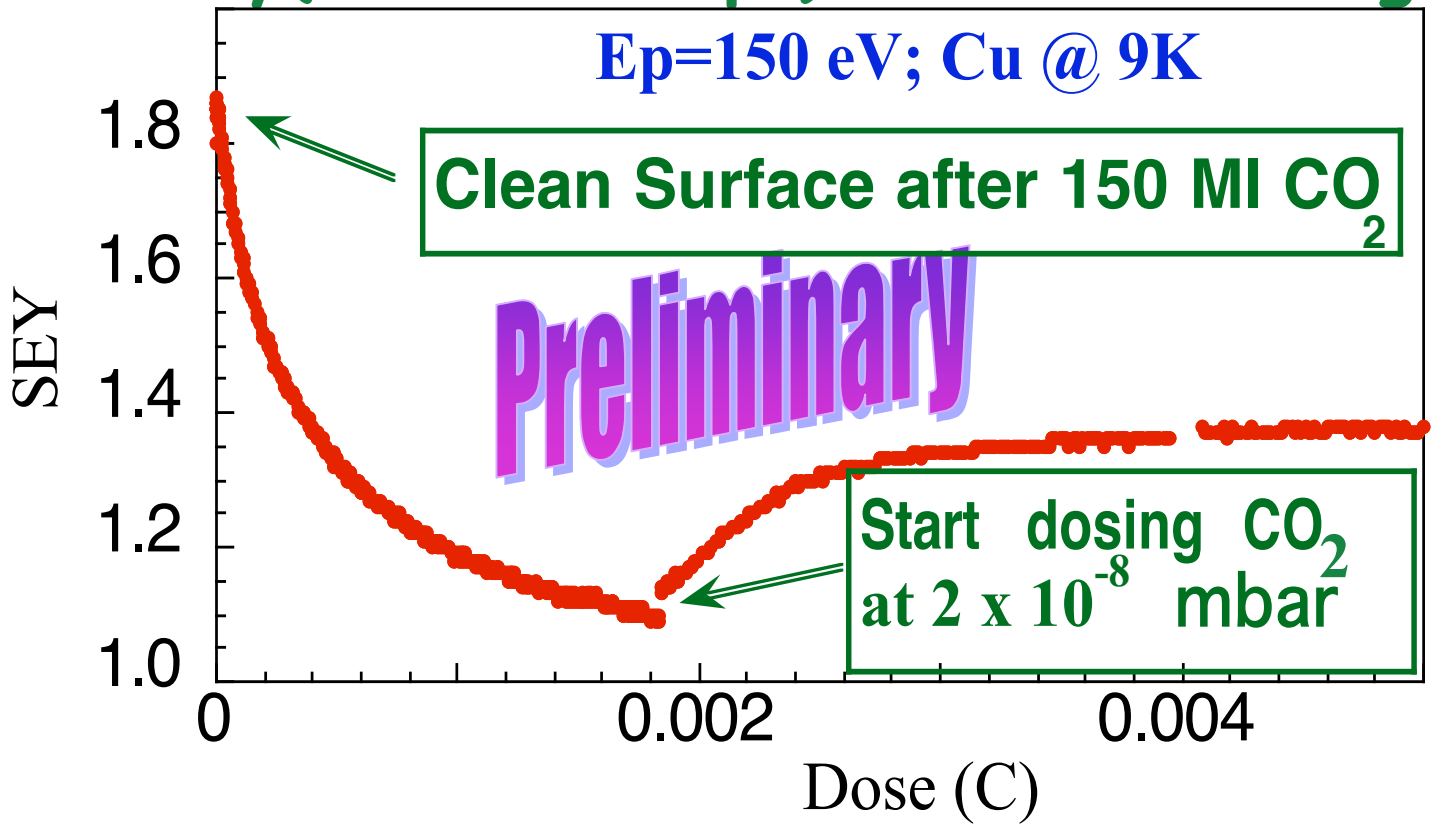


Not significantly! In an open geometry!

2) "open" vs. "close" geometry.

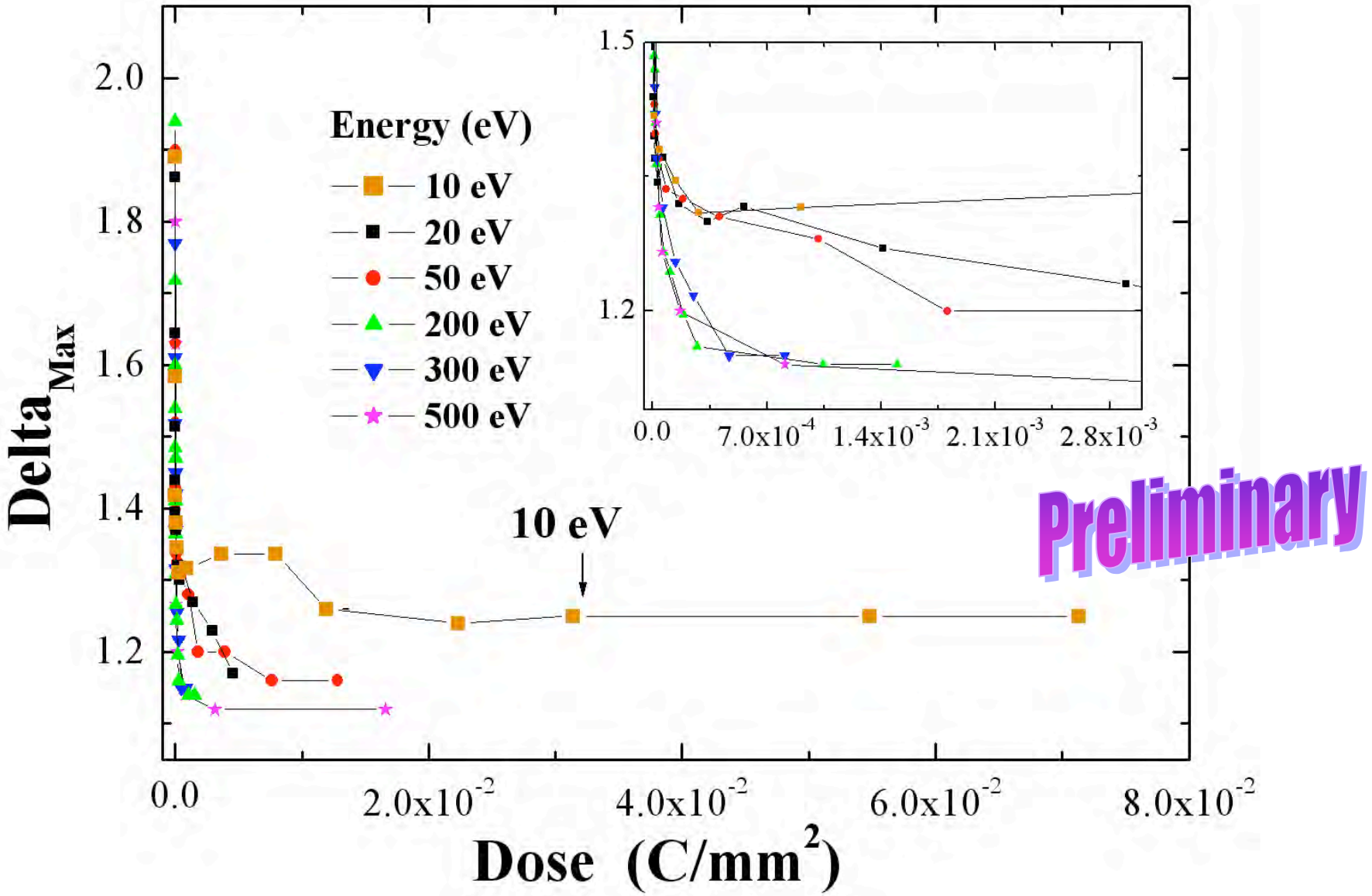
At LT we may be in presence of a thick layer of gas

Close geometry(first attempt) => continuous gas dosing!



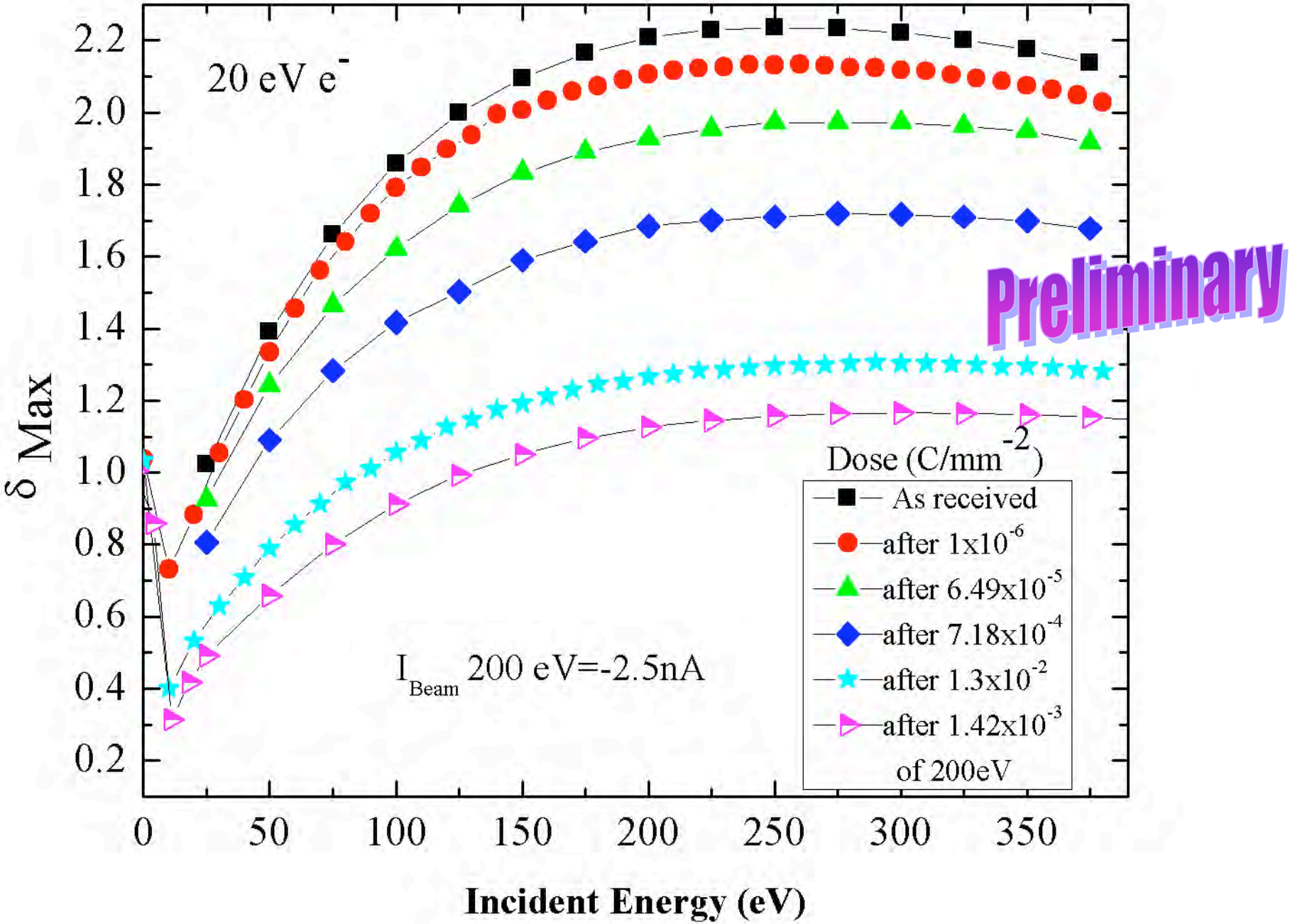
scrubbing at LT while dosing seems to change things! ===> To be continued!!!

3) Dose= N°e⁻(Amps) x t(s) /A (mm²) But: do 100 e⁻ @ 500 eV scrub as 100 e⁻ @ 20 eV?

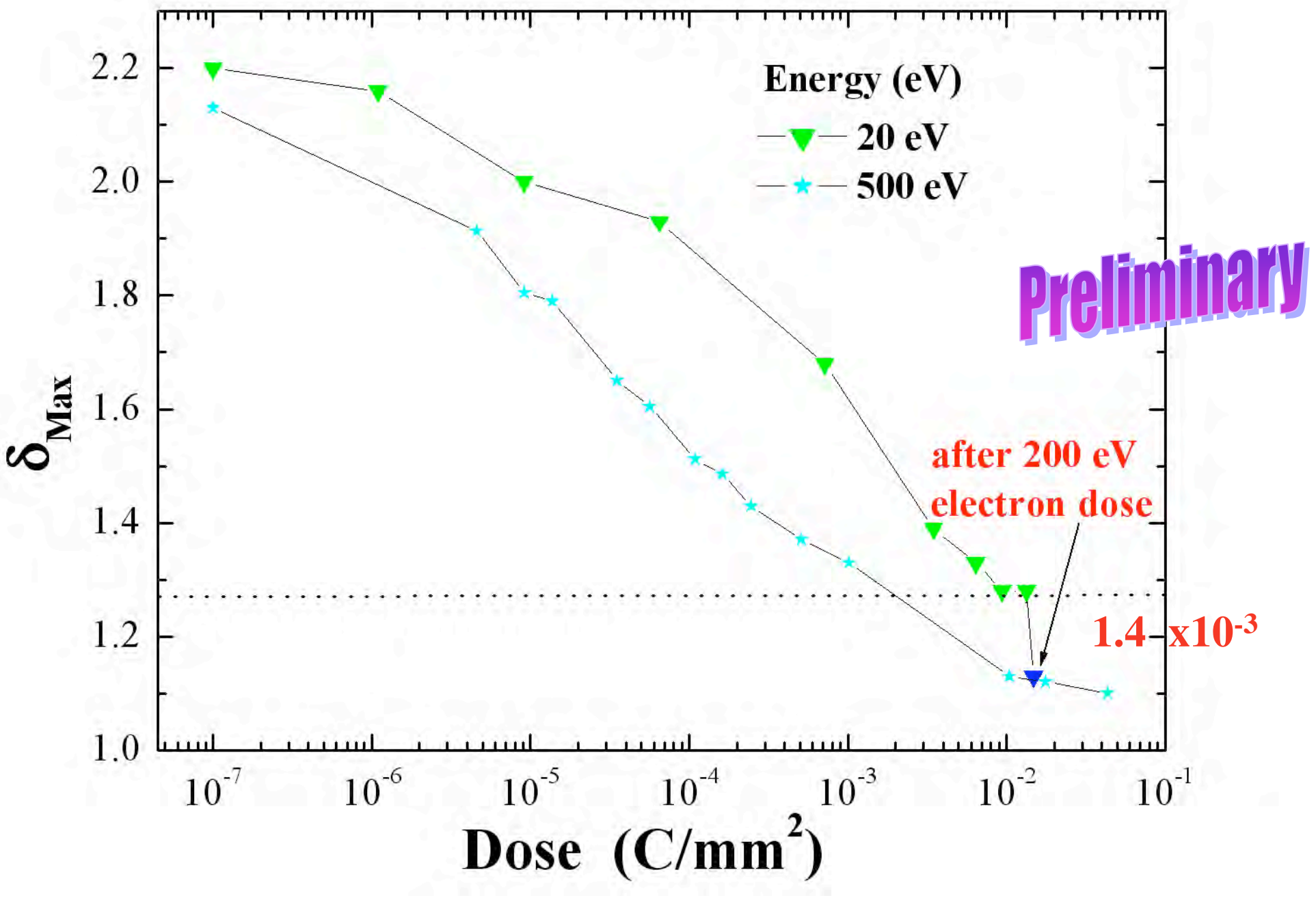


Preliminary

3) Let us look in more details at @ 20 eV



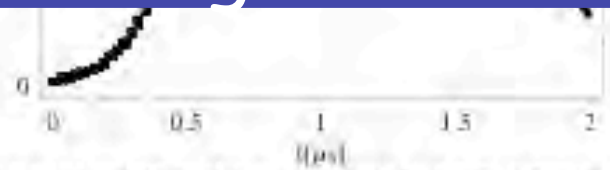
Comparing scr. @ 20 eV with scr. @ 500 eV



The actual energy of the e^- responsible for the scrubbing seems to affect its scrubbing efficiency. Since most of the e^- in the cloud do have energies less than 20 eV, this data could have significant implications to optimize machine commissioning operation.

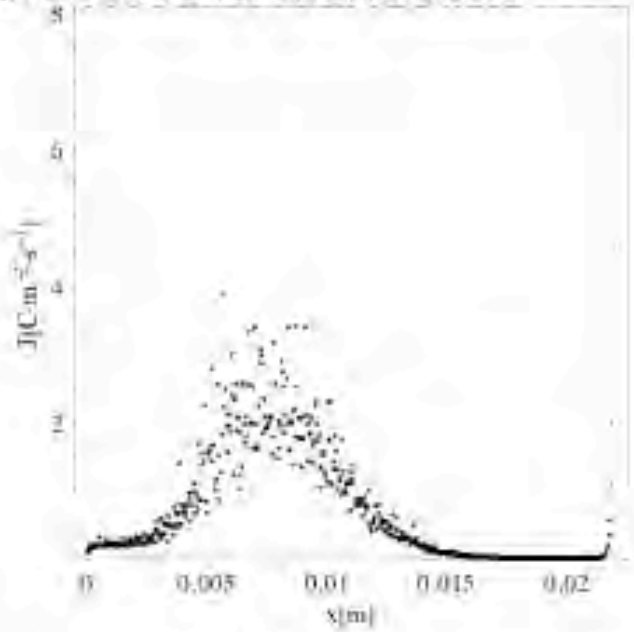
In simulations each electron must be "dressed" with his scrubbing efficiency associated to its energy.

Simulation (thanks to Theo Demma) tell us that more than 50% of the electrons in the beampipe have energies less than 30 eV

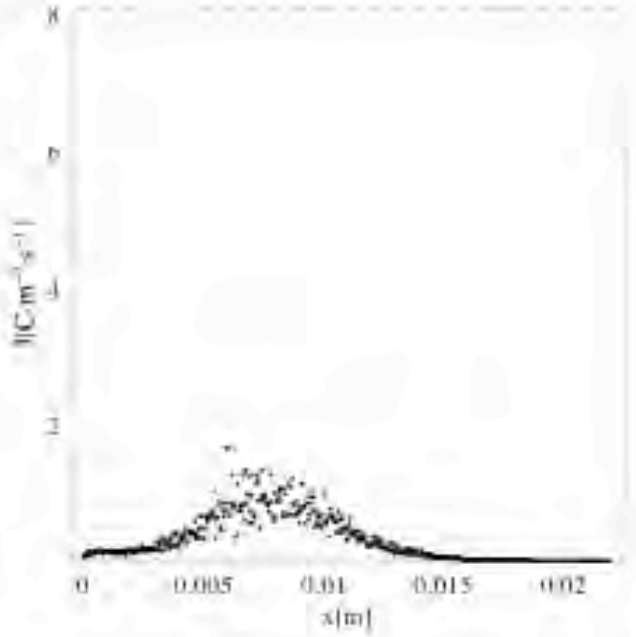


linear electron density evolution computed with ECLOUD for an LHC dipole

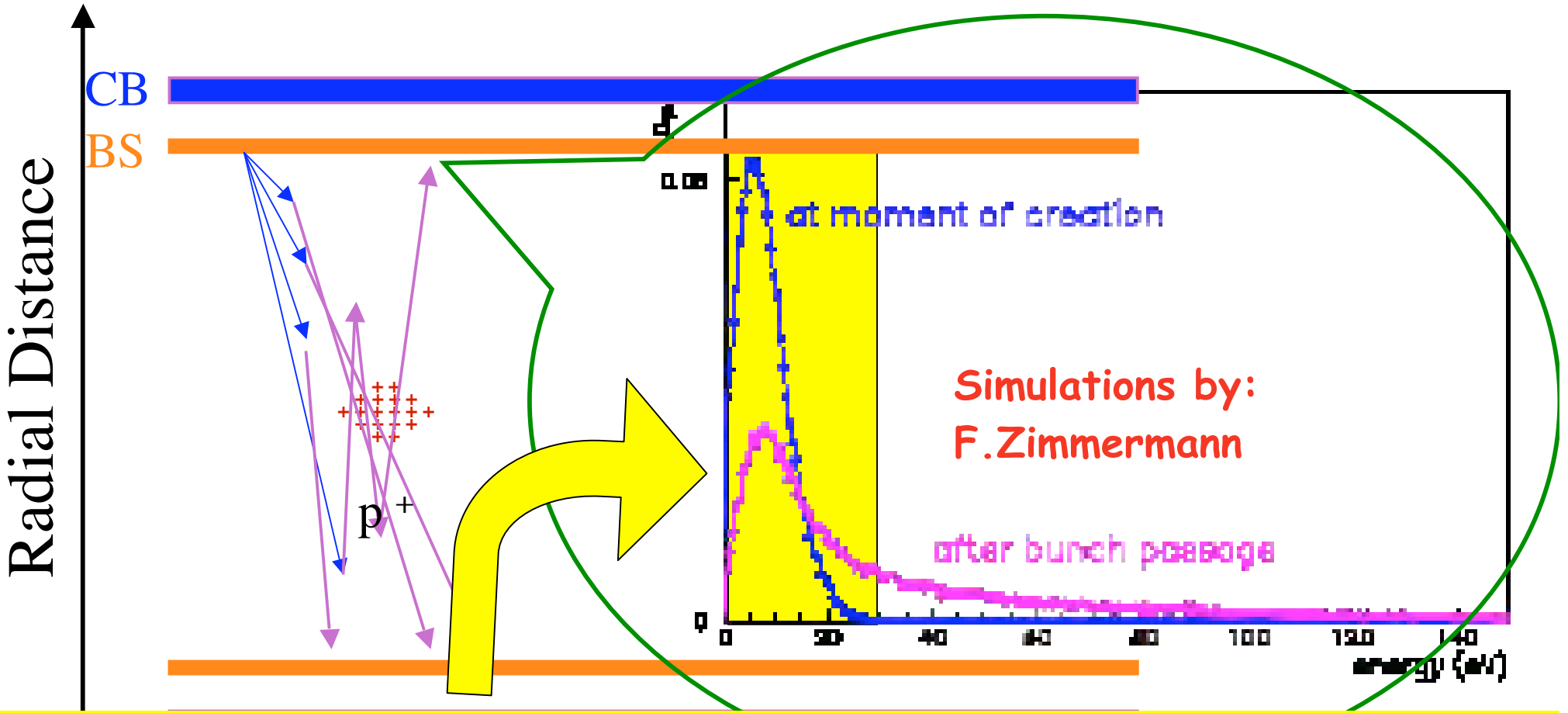
circumference	m	27000
primary photo-emission yield	-	$7.98 \cdot 10^{-4}$
maximum SEY δ_{max}	-	1.8
energy for max. SEY E_{max}	eV	237.125



average electron charge hitting the wall as a function of horizontal position in the chamber.



average electron charge hitting the wall with energy > 30 eV as a function of horizontal position in the chamber.

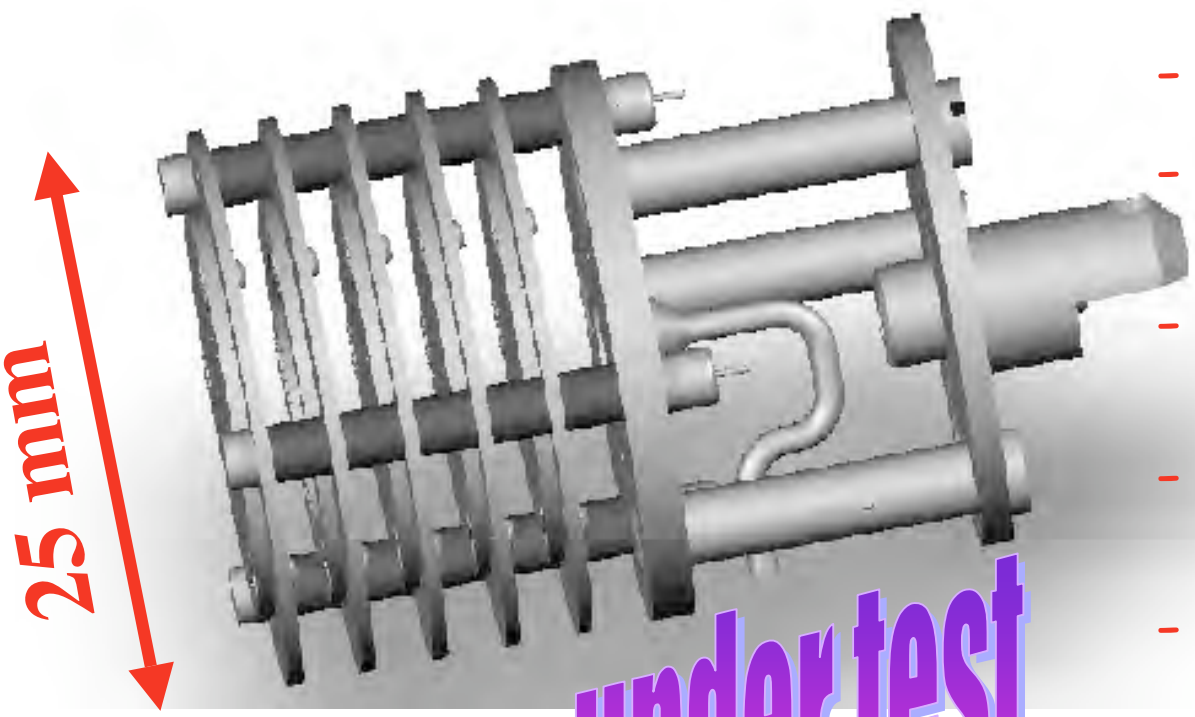


What happens if these el. do not Scrub??

How long will it take for commissioning LHC?

Can we measure the actual e^- energy?

At DaΦne (maybe at Anka SPS or LHC) we plan to measure e^- en. by inserting in the machine Energy-resolved El. Detectors.



under test

- First grid at ground
- energy resolution
- heterodyne technique for noise reduction
- channelplate for high counting rates
- Sensitivty to low energy electrons
- Use of commercial electronics

It is important to benchmark simulated prediction of the energy distr. of e^- cloud related electrons on the wall with actual measurements in accelerators (SPS may be ideal since it has no ph e^-).

Further laboratory study on scrubbing efficiency Vs energy for all material is than mandatory and is in progress @ LNF. Such studies will be valuable not only for LHC, but also for DAΦNE-II, ILC - DR and high luminosity Super-B.

For LHC it should be possible to find beam parameters which generate high energy electrons to reduce scrubbing time!

A common effort and a closer collaboration between the different laboratories active in the field will be extremely beneficial if not absolutely necessary (also for man power recruitment).

Acknowledgments:

- M. Commisso, T. Demma, C. Vaccarezza, M.Biagini, P. Barone, A. Bonanno, S. Guiducci, M. Zobov, A. Drago and the LNF-INFN accelerator group

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